

REFERENCE TABLES
Instructions and Examples

Following is an example of how to use the reference tables when determining crop water requirements and sprinkler spacing.

EXAMPLE PARAMETERS: An alfalfa / lucerne crop is to be irrigated on level ground. The soil is medium type. Climate is hot. For convenience of labor, two eleven-hour sets per day will be used. Normal sprinkler spacing of 30 ft x 50 ft / 9x15 meters will be used. Average wind speed is 4 mph / 6 km/hr.

Use the following steps:

- From **Plant Feeder Root Depth (TABLE 1)**, alfalfa / lucerne roots are three feet / 90 cm deep.
- Determine **Soil Type (TABLE 2)**. From **Net Amount of Moisture per Application (TABLE 2)**, three feet / 90 cm depth in medium soil with 50% moisture retained at irrigation means 2.53 inches / 63,3 mm net must be applied per irrigation.
- From **Peak Moisture (TABLE 3)**, alfalfa / lucerne uses 0.30 inches / 7,5 mm per day in hot climate.
- Irrigation frequency or interval between irrigation is determined by dividing net moisture applied during irrigation by peak moisture use of the crop per day. For example, the irrigation frequency or interval is 2.53 inches / 63,3 mm net divided by 0.30 inches / 7,5 mm per day peak moisture use or 8.4 days.
- From **Gross Amount of Moisture (TABLE 4)**, 2.53 inches / 65mm net is 3.57 inches / 92,95 mm gross in a hot climate with 70% irrigation efficiency. Also see additional example (TABLE 5) estimating irrigation efficiencies.
- Precipitation rate in inches / millimeters per hour is determined by dividing gross moisture in inches / millimeters by number of hours per set. For example, the required precipitation rate is determined by dividing 3.57 inches / 92,95 mm by 11 hours per set or 0.32 inches / 8,45 mm per hour.
- From **Maximum Precipitation Rate (TABLE 6)** for medium soil, maximum rate is from 0.25 to 0.5 inches / 6 to 12 mm per hour. Therefore, precipitation rate of 0.32 inches / 8,45mm per hour in step 6 is satisfactory.
- Use **Slope Precipitation (TABLE 7)** to reduce precipitation due to slope of ground.
- From **Table of Precipitation (TABLE 8)** on 30 ft x 50 ft / 9x15 meter spacing with a precipitation rate of 0.32 inches / 8,45 mm per hour, a 5 gpm / 1,08 m³/hr sprinkler is required.
- From the **Rain Bird Agriculture Irrigation Equipment Catalog** a 30WH Rain Bird with 5/32 inches / 3,97 mm nozzle discharges 5 gpm / 1,16 m³/hr at 50 PSI / 3,5 bars with a 90 ft / 13,64 m diameter of throw.
- From **Maximum Spacing of Sprinklers (TABLE 9)**, 40% of diameter between sprinklers and 65% of diameter between laterals may be used in winds up to 7 mph / 10 km/hr. Diameter of 90 ft / 27,28 m times 40% and 65% give a theoretical spacing of 36 ft x 58.5 ft / 10,9 x 17,7 meters. A spacing of 30 ft x 50 ft / 9x15 meters will give good coverage.

TABLE 1
Plant Feeder Root Depths*

Crop	Feeder Root Depth	
Alfalfa / lucerne	90-180 cm	3-6 ft
Beans	60 cm	2 ft
Beets	60-90 cm	2-3 ft
Berries (cane)	90 cm	3 ft
Cabbage	45-60 cm	1.5-2 ft
Carrots	45-60 cm	1.5-2 ft
Corn	75 cm	2.5 ft
Cotton	120 cm	4 ft
Cucumbers	45-60 cm	1.5-2 ft
Grain	60-75 cm	2-2.5 ft
Grain, Sorghum	75 cm	2.5 ft
Grapes	90-180 cm	3-6 ft
Lettuce	30 cm	1 ft
Melons	75-90 cm	2.5-3 ft
Nuts	90-180 cm	3-6 ft
Onions	45 cm	1.5 ft
Orchard	90-150 cm	3-5 ft
Pasture (grasses only)	45 cm	1.5 ft
Pasture (with clover)	60 cm	2 ft
Peanuts	45 cm	1.5 ft
Peas	75 cm	2.5 ft
Potatoes	60 cm	2 ft
Soy Beans	60 cm	2 ft
Strawberries	30-45 cm	1-1.5 ft
Sweet Potatoes	90 cm	3 ft
Tobacco	75 cm	2.5 ft
Tomatoes	30-60 cm	1-2 ft

* Majority of Feeder Roots

RAIN BIRD NOZZLES
Equivalency Chart

Size in Inches	Size in mm	Order Number
1/16"	1,59	04
5/64"	1,98	05
3/32"	2,38	06
7/64"	2,78	07
1/8"	3,18	08
9/64"	3,57	09
5/32"	3,97	10
11/64"	4,37	11
3/16"	4,76	12
13/64"	5,16	13
7/32"	5,56	14
15/64"	5,95	15
1/4"	6,35	16
17/64"	6,75	17
9/32"	7,14	18
19/64"	7,54	19
5/16"	7,94	20
11/32"	8,73	22
3/8"	9,53	24
13/32"	10,32	26
7/16"	11,11	28
15/32"	11,91	30
1/2"	12,70	32
17/32"	13,49	34
9/16"	14,29	36
5/8"	15,88	40
11/16"	17,46	44

TABLE 2
NET AMOUNT OF MOISTURE PER APPLICATION

Root Zone Depth	cm	LIGHT SANDY SOIL TYPE						MEDIUM SOIL TYPE						HEAVY SOIL TYPE					
		30	45	60	75	90	120	30	45	60	75	90	120	30	45	60	75	90	120
a. Field Capacity	mm	31,0	47,0	62,5	78,0	93,7	125,0	56,0	84,5	112,5	140,5	168,7	225,0	92,0	137,5	183,5	229,0	275,0	367,0
b. Amount held at wilting point (a x %)	Percent mm	20%	20%	20%	20%	20%	20%	25%	25%	25%	25%	25%	25%	35%	35%	35%	35%	35%	35%
		6,0	9,4	12,5	15,6	18,7	25,0	14,0	21,0	28,0	35,0	42,0	56,0	32,0	48,0	64,0	80,0	96,0	128,5
c. Available moisture for plant use (a - b) = c	mm	25,0	37,6	50,0	62,4	75,0	100,0	42,0	63,5	84,5	105,5	126,7	169,0	60,0	89,5	119,5	149,0	179,0	239,5
Net mm to apply per irrigation	67%	8,2	12,4	16,5	20,6	25,0	33,0	14,0	21,0	27,9	34,0	41,9	56,0	19,8	29,6	39,0	49,2	59,1	79,0
with appropriate % of available	50%	12,5	18,8	25,0	31,2	37,5	50,0	21,0	31,8	42,2	52,8	63,3	84,5	30,0	44,8	59,8	74,5	89,5	119,8
moisture retained in soil at irrigation (see note below)	33%	16,8	25,2	33,5	41,8	50,0	67,0	28,0	42,5	56,6	70,7	84,8	113,0	40,2	60,0	80,0	99,8	119,9	160,5

NOTE: For optimum yield of high-valued, shallow-rooted crops maintain **67%** available moisture. For lower-valued, deeper-rooted crops maintain **50%** available moisture. For low-value, deep-rooted crops maintain **33%** available moisture.

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Reference Tables (continued)

TABLE 3
Peak Moisture Use for Common Irrigated Crops and Optimum Yields*

Crop	COOL Climate			MODERATE Climate			HOT Climate			HIGH DESERT Climate			LOW DESERT Climate		
	mm/day	m ³ /hr/hectare	lps/hectare	mm/day	m ³ /hr/hectare	lps/hectare	mm/day	m ³ /hr/hectare	lps/hectare	mm/day	m ³ /hr/hectare	lps/hectare	mm/day	m ³ /hr/hectare	lps/hectare
Lucerne (Alfalfa)	5,00	20,52	0,57	6,25	25,92	0,72	7,50	31,32	0,87	8,75	36,36	1,01	11,25	46,80	1,30
Cotton	5,00	20,52	0,57	6,25	25,92	0,72	7,50	31,32	0,87	8,75	36,36	1,01	11,25	46,80	1,30
Pasture	5,00	20,52	0,57	6,25	25,92	0,72	7,50	31,32	0,87	8,75	36,36	1,01	11,25	46,80	1,30
Grain	3,75	15,48	0,43	5,00	20,52	0,57	5,50	22,68	0,63	7,50	31,32	0,87	10,00	41,76	1,16
Potatoes	3,50	14,40	0,40	5,00	20,52	0,57	6,25	25,92	0,72	7,50	31,32	0,87	10,00	41,76	1,16
Beets	5,00	20,52	0,57	6,25	25,92	0,72	7,50	31,32	0,87	8,75	36,36	1,01	11,25	46,80	1,30
Orchards & Groves	5,00	20,52	0,57	6,25	25,92	0,72	7,50	31,32	0,87	8,75	36,36	1,01	11,25	46,80	1,30
Orchards & Groves w/cover	6,25	25,92	0,72	7,00	29,16	0,81	8,75	36,36	1,01	9,50	39,60	1,10	12,00	50,04	1,39

*Continuous flow required per acre at 100% irrigation efficiency. Divide this value by estimated irrigation efficiency (see TABLE 5).

TABLE 4
Gross Amount of Moisture to Apply to Obtain Desired Net in Different Climates¹

Desired Net Millimeters	COOL Climate Gross mm @ 80% Efficiency	MODERATE Climate Gross mm @ 75% Efficiency	HOT Climate Gross mm @ 70% Efficiency	HIGH DESERT Climate Gross mm @ 65% Efficiency	LOW DESERT Climate Gross mm @ 60% Efficiency
5,00	6,25	6,65	7,15	7,70	8,30
6,00	7,50	7,98	8,58	9,24	9,96
7,00	8,75	9,31	10,01	10,78	11,62
8,00	10,00	10,64	11,44	12,32	13,28
9,00	11,25	11,97	12,87	13,86	14,24
10,00	12,50	13,30	14,30	15,40	16,60
15,00	18,75	19,95	21,45	23,10	24,90
20,00	25,00	26,60	28,60	30,80	33,20
25,00	31,25	33,25	35,75	38,50	41,50
30,00	37,50	39,90	42,90	46,20	49,80
35,00	43,75	46,55	50,05	53,90	58,10
40,00	50,00	53,20	57,20	61,60	66,40
45,00	56,25	59,85	64,35	69,30	74,70
50,00	62,50	66,50	71,50	77,00	83,00
55,00	68,75	73,15	78,65	84,70	91,30
60,00	75,00	79,80	85,80	92,40	99,60
65,00	81,25	86,45	92,95	100,10	107,90
70,00	87,50	93,10	100,10	107,80	116,20
75,00	93,75	99,75	107,25	115,50	124,50
80,00	100,00	106,40	114,40	123,20	132,80
85,00	106,25	113,05	121,55	130,90	141,10
90,00	112,50	119,70	128,70	138,60	149,40
95,00	118,75	126,35	135,85	146,30	157,70
100,00	125,00	133,00	143,00	154,00	166,00
105,00	131,25	139,65	150,15	161,70	174,30
110,00	137,50	146,30	157,30	169,40	182,60

¹ Very low application rate systems can attain 80% efficiency in all climate areas.

TABLE 5
Estimating Irrigation Efficiencies

Desert Climate	65%
Hot Dry Climate	70%
Moderate Climate	75%
Humid or Cool Climate	80%

Example: For a 50mm requirement in a hot-dry climate,

$$\frac{50\text{mm}}{0.70} \times 10 \frac{\text{m}^3/\text{hectare}}{\text{mm applied}} = 714 \text{ m}^3/\text{hectare}$$

Thus: 714 m³/hectare water applied each irrigation

TABLE 6
Maximum Precipitation Rates to Use on Level Ground

Light sandy soils	18 - 12 mm per hour
Medium textured soils	12 - 6 mm per hour
Heavy textured soils	6 - 2.5 mm per hour

Allowable rates increase with adequate cover and decrease with land slopes and time.

TABLE 7
Slope Precipitation Table

Slope ¹	Precipitation Rate Reduction ²
0 - 5 % grade	0 %
6 - 8 % grade	20 %
9 - 12 % grade	40 %
13 - 20 % grade	60 %
over 20 % grade	75 %

¹ Grade = drop in 100 meters

² Applied to proper soil type precipitation rate

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Reference Tables (continued)

TABLE 8*
Table of Precipitation (mm per hour)

Spacing (meters)	Flow from each Full Circle Sprinkler																											
	m3/hr ips	0,18 0,05	0,36 0,10	0,56 0,15	0,72 0,20	0,90 0,25	1,08 0,30	1,44 0,40	1,80 0,50	2,16 0,60	2,52 0,70	2,88 0,80	3,24 0,90	3,60 1,00	3,96 1,10	4,32 1,20	5,40 1,50	6,40 1,80	7,20 2,00	9,00 2,50	10,8 3,00	18,0 5,00	36,0 10,0	72,0 20,0	108 30,0	216 60,0		
6 x 6	5,00	10,0	15,0	20,0	25,0	30,0	40,0	50,0																				
6 x 9	3,30	6,60	10,0	13,3	16,6	20,0	26,6	33,3	40,0	46,6	53,0																	
6 x 12	2,50	5,00	7,50	10,0	12,5	15,0	20,0	25,0	30,0	35,0	40,0	45,0	50,0															
8 x 8	2,80	5,60	8,40	11,2	14,0	16,9	22,5	28,1	33,7	39,4	45,0	50,0																
9 x 9	2,20	4,40	6,60	8,90	11,1	13,3	17,8	22,2	26,6	31,1	35,5	40,0	44,4	48,8	53,3													
9 x 12	1,60	3,30	5,00	6,60	8,30	10,0	13,3	16,6	20,0	23,3	26,6	30,0	33,3	36,6	40,0	50,0	59,2											
9 x 14	1,40	2,80	4,30	5,70	7,10	8,60	11,4	14,3	17,1	20,0	22,8	25,7	28,5	31,4	34,3	42,8	50,8											
9 x 15	1,30	2,70	4,00	5,30	6,60	8,00	10,6	13,3	16,0	18,6	21,3	24,0	26,6	29,4	32,0	40,0	47,4											
9 x 18		2,20	3,30	4,40	5,50	6,60	8,90	11,1	13,3	15,5	17,8	20,0	22,2	24,4	26,6	33,3	39,5	44,4	55,5									
12 x 12		2,50	3,70	5,00	6,20	7,50	10,0	12,5	15,0	17,5	20,0	22,5	25,0	27,5	30,0	37,5	44,4	50,0	62,5									
12 x 15		2,00	3,00	4,00	5,00	6,00	8,00	10,0	12,0	14,0	16,0	18,0	20,0	22,0	24,0	30,0	35,5	40,0	50,0									
12 x 18		1,60	2,50	3,30	4,20	5,00	6,60	8,30	10,0	11,6	13,3	15,0	16,6	18,3	20,0	25,0	29,6	33,3	41,6	50,0								
15 x 15				3,20	4,00	4,80	6,40	8,00	9,60	11,2	12,8	14,4	16,0	17,6	19,2	24,0	28,4	32,0	40,0	48,0								
15 x 18				2,60	3,30	4,00	5,30	6,60	8,00	9,30	10,6	12,0	13,3	14,6	16,0	20,0	23,7	26,6	33,3	40,0								
15 x 21				2,30	2,80	3,40	4,60	5,70	6,80	8,00	9,10	10,3	11,4	12,6	13,7	17,1	20,3	22,8	28,5	34,3								
18 x 18						3,30	4,40	5,50	6,60	7,80	8,90	10,0	11,1	12,2	13,3	16,6	20,0	22,2	27,7	33,3								
18 x 21						2,80	3,80	4,70	5,70	6,60	7,60	8,60	9,50	10,5	11,4	14,3	16,9	19,0	23,8	28,6								
18 x 24						2,50	3,30	4,20	5,00	5,80	6,60	7,50	8,30	9,10	10,0	12,5	14,8	16,6	20,8	25,0								
21 x 21						2,40	3,20	4,10	4,90	5,70	6,50	7,30	8,10	8,90	9,80	12,2	14,5	16,3	20,4	24,5	40,8							
21 x 24							2,80	3,60	4,30	5,00	5,70	6,40	7,10	7,80	8,60	10,7	12,7	14,3	17,8	21,4	35,7							
21 x 27							2,50	3,20	3,80	4,40	5,10	5,70	6,30	7,00	7,60	9,50	11,3	12,7	15,9	19,0	31,7							
24 x 24								3,10	3,70	4,30	5,00	5,60	6,20	6,90	7,50	9,40	11,1	12,5	15,6	18,7	31,2							
24 x 30								2,50	3,00	3,50	4,00	4,50	5,00	5,50	6,00	7,50	8,90	10,0	12,5	15,0	25,0							
28 x 33										2,30	2,70	3,10	3,50	3,90	4,30	5,80	6,90	7,80	9,70	11,7	19,4	38,9						
30 x 30										2,40	2,80	3,20	3,60	4,00	4,40	6,00	7,10	8,00	10,0	12,0	20,0	40,0						
30 x 36											2,30	2,60	3,00	3,30	3,60	5,00	5,90	6,60	8,30	10,0	16,6	33,3						
35 x 41													2,50	2,70	3,00	3,70	4,40	5,00	6,30	7,50	12,5	25,0	50,1					
45 x 45																2,60	3,20	3,50	4,40	5,30	8,90	17,7	35,5	53,3				
45 x 54																2,60	2,90	3,70	4,40	5,30	7,40	14,8	29,6	44,4				
60 x 60																		2,50	3,00	5,00	10,0	20,0	30,0	60,0				
90 x 90																				2,20	4,40	8,80	13,3	26,6				
100 x 100																					3,60	7,20	10,8	21,6				

TABLE 9
Maximum Spacing of Sprinklers

The maximum spacing of sprinklers is based on the diameter of coverage of the sprinkler used.

Average Wind Speed: Up to 10 km/hr

- Spacing
- 40% between sprinklers
- 65% between laterals

Average Wind Speed: 10 to 15 km/hr

- Spacing
- 40% between sprinklers
- 60% between laterals

Average Wind Speed: above 15 km/hr

- Spacing
- 30% between sprinklers
- 50% between laterals

*Calculation of Flow From Each Full Circle Sprinkler

$$\text{Spacing} \times \frac{\text{Precipitation Rate}}{1000} = \text{Flow from each Full Circle Sprinkler}$$

EXAMPLE:

$$9\text{m} \times 15\text{m} \times \frac{8,45 \text{ m/hr}}{1000} = 1,14 \text{ m}^3/\text{hr}$$